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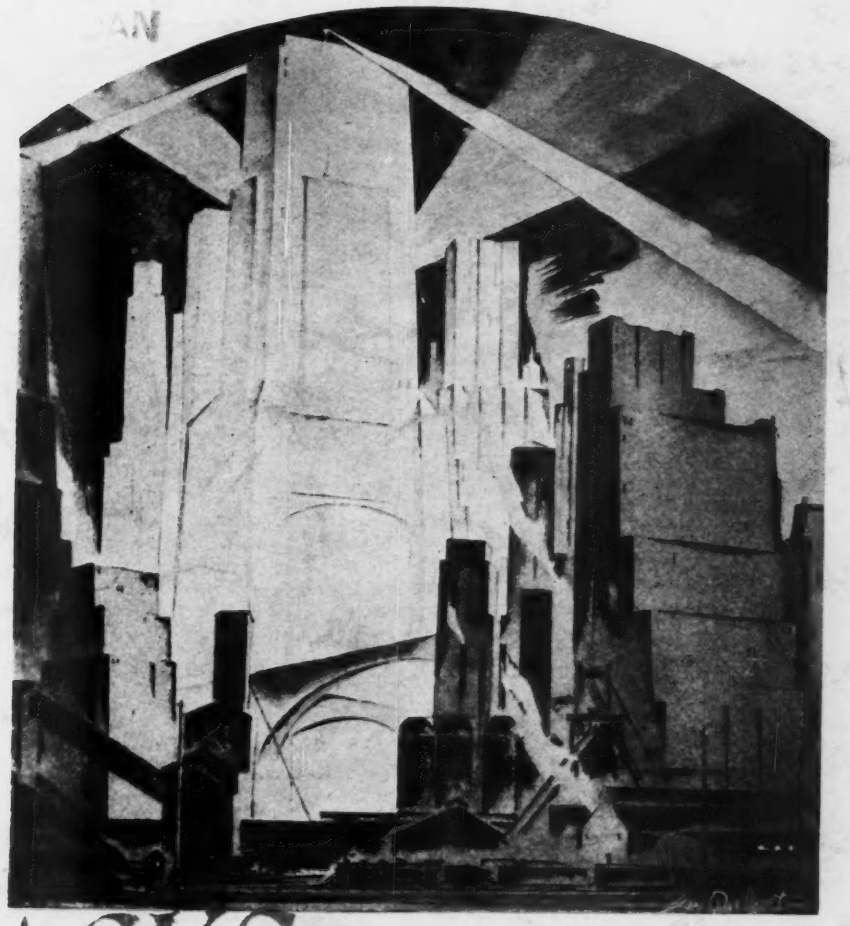


STACKS

FEATURING

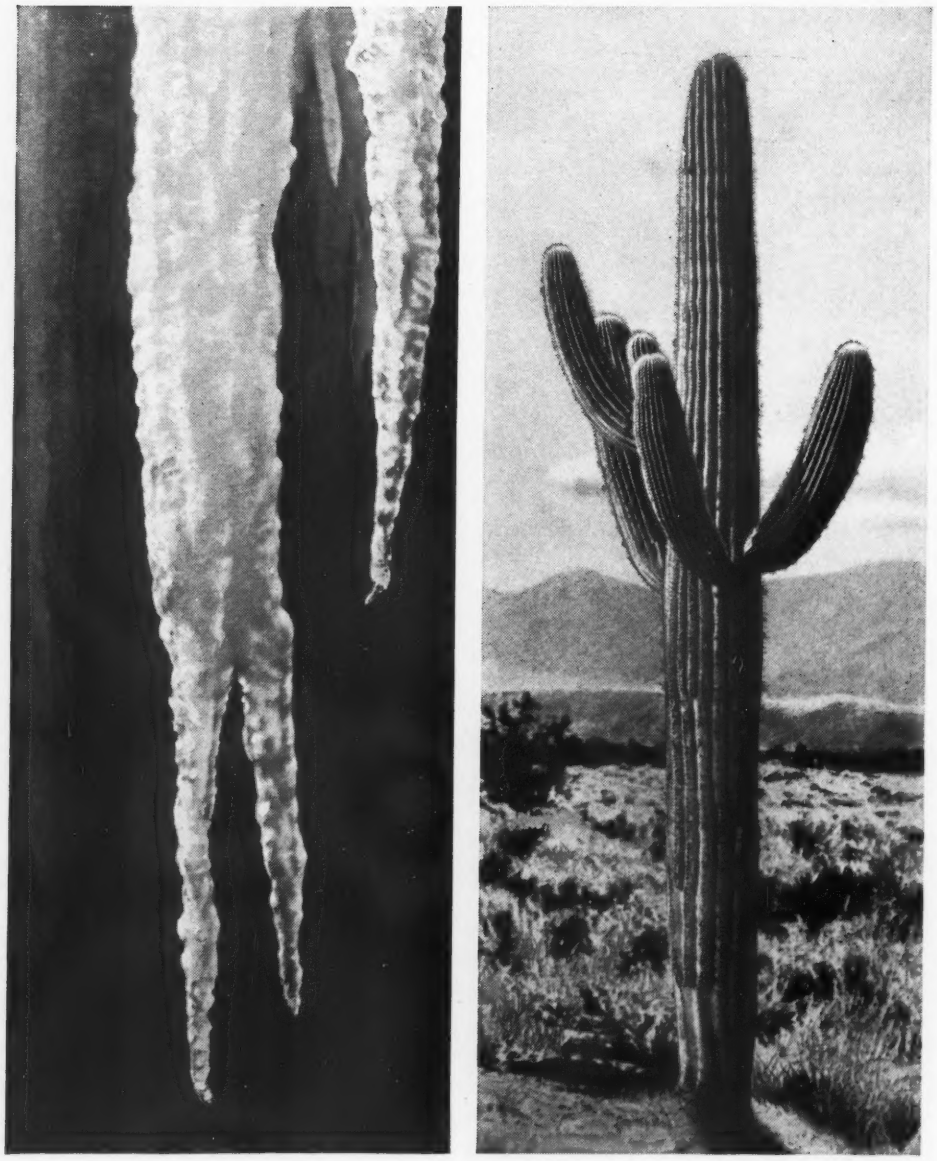
Early Chinese Alchemists

By TENNEY L. DAVIS

Protecting Your Eyes

By PARRY L. MOON '27

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



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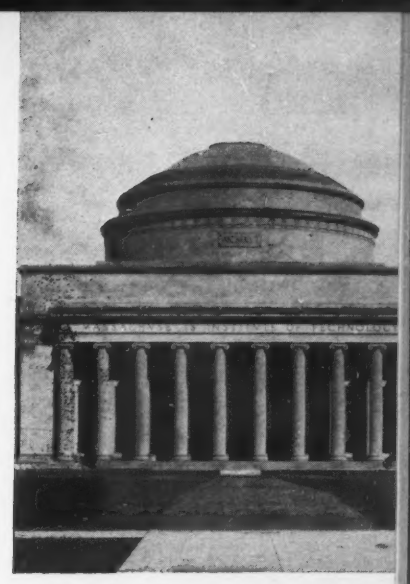

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Editor-in-Chief

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PLUMES
of
LIGHT

Stories of

EARLY CHINESE ALCHEMISTS

—*First to Practice The Art*

By TENNEY L. DAVIS
Associate Professor of Organic Chemistry
Massachusetts Institute of Technology

THE chemical arts are exceedingly ancient. Early man used for his purposes the materials which nature provided, for his tools first stone and later the naturally occurring metals, copper, silver, gold, and meteoric iron. With the mastery of fire he commenced to produce the metals artificially from their ores and by chemical means to prepare many of the materials and objects which characterize civilization as distinct from utter savagery. From that time forth the chemical arts have flourished. They are coeval with mankind's emergence into *homo sapiens*. It is impossible to discuss the origins of chemistry.

The origins of alchemy are another matter. The chemical arts yielded marvelous results; in the earliest civilizations of which we have knowledge they supplied the comforts and amenities of life, objects of beauty, and medicines which definitely cured or alleviated many diseases. It seemed that anything might be expected from them. The hope appeared that chemical processes might be able to convert base metals into authentic gold and to yield a medicine which should secure longevity or actual immortality to the person who should use it. The pursuit of the hope was alchemy.

Chemical processes for the production of objects of beauty and luxury, dyes, pigments, glass, enamels, cosmetics, and alloys of various colors, were practiced as a secret art in the temple workshops of Egypt. Knowledge of them at length found its way through Alexandria to Byzantium and thence to Europe. The Alexandrians were interested in altering the colors of their metals and the outward appearance of their materials. But they did not pretend that their yellow alloys were authentic gold; they knew them to be imitations and did not dream that they had accomplished an actual transmutation. They prepared medicines to be sure, but were not engaged in a pursuit of an elixir of immortality. Alchemy was not primitive chemistry as some have called it (the origin of primitive chemistry cannot be discussed); and there is no evidence that alchemy came to Europe from Alexandria—to which city and culture Europe is undoubtedly indebted for much that is purely chemical knowledge.

Alchemy appears to have arisen spontaneously in China about the third century B. C. as an offshoot from the magical and fantastic side of the Taoist religion. The alchemists were Taoists and their writings, preserved to us in the Taoist canon, are the earliest known texts on alchemy. They worked with metals and minerals, animal and vegetable products, converted base metals into gold (as they report), and prepared the pill of immortality. Gold did not interest the Chinese alchemists for its intrinsic value, but artificial gold had the magical property of imparting longevity to the person who ate out of vessels made from it. Taoism promised no individual immortality to its devotees, but the pill of immortality converted the user into a *hsien*, or supernatural immortal endowed with extraordinary powers, who could change his appearance at will, pass through fire unburned, and traverse great distances in an instant of time.

The best evidence at present available indicates that alchemy probably came to Europe from China, across Persia to the Arabs whom we find first practicing the art in the eighth century A. D., using the same materials and processes as the Chinese alchemists, the same rhetoric and the same secrecy. The Arabs however did not seek for a pill of immortality but only for an elixir of longevity, for their religion gave them promise of an eternal life. The Latin alchemical treatises of the Middle Ages, following the

Journal of Chemical Education

Ko Hung — "probably the most outstanding figure in the history of Chinese Alchemy."

Arabic tradition, have a remarkable similarity to the Chinese treatises in style and in content.

While a certain amount of information concerning Chinese alchemy has been accessible for some time to European scholars, our knowledge of the subject has been greatly increased within the past few years by the efforts of Dr. Lu-Ch'iang Wu (M. I. T., B.S. 1928; Ph.D. 1931) who has translated the earliest known treatise in Chinese, or in any language, which is devoted exclusively to the subject of alchemy, the *Ts'an T'ung Ch'i* of Wei Po-yang, also the chapter on the Gold Medicine of Ko Hung, the greatest of the Chinese alchemists, and the accounts of the lives of a number of alchemists which are printed in the ancient *Lieh Hsien Ch'üan chuan* (Complete Biographies of the Immortals). In the following the quotations are from Dr. Wu's translations. Some of them have not before been published.

The Chinese alchemists knew their art by the name of *Huang-Lao,* a word compounded from the name of Lao-tzŭ or Lao-chun, the founder of Taoism, and from that of Huang-ti, the legendary Yellow Emperor, reputed and perhaps mythical founder of alchemy, who lived, if at all, about 2400 B.C.

Huang-ti humbly sought knowledge of the *Tao* (Way) in the cave of the sage, Kuang-ch'eng-tzŭ. It is told of him that after he received the instruction — "In the daytime his spirit visited the country of the Hua-hsu-shih. It was situated west of Yen-chou and north of T'ai-chou. It was tens of thousands of miles away from the Middle Empire. The actual distance was not known for it could not be reached by wheel or by boat or even on foot. One could get there only in spirit. The country was without rulers. Its people had no indulgences. They did not love to live, nor did they loathe to die. And so they did not die untimely deaths. They did not hold themselves dear and they showed indifference to things. And so they did not have love and hatred. They did not turn against those who opposed them or favor those who agreed with them. And so they were not concerned with losses and gains. They were without love and favor. They were free from fear and hatred. They were not wet by water nor heated by fire. They were wont to stay in space as if it were solid and to lie in emptiness as if it were a bed. Clouds and fogs did not interfere with their power. Thunder and lightning did not trouble their hearing. Good and evil did not bother their hearts. Mountains and peaks did not hinder their steps. For it was the spirit that was moving about."

At a later time Huang-ti procured copper, fashioned it into a *ting* (tripod, alchemical furnace), and ascended the dragon with some seventy members of his court and household.

Liu An (died 122 B.C.), prince of Huai Nan and grandson of the first Han Emperor, Kao-ti, is mentioned by Wei Po-yang and others as one of the early masters of the art. It is reported that his writings contained references to alchemy, but the only one which has survived to us, a treatise entitled *Huai-nan-tzŭ* which is included in the Taoist canon, is an account of cosmogony based upon the *Yin-Yang* doctrine.

The story goes that eight *hsien* came to the court of Liu An. "One of us can cause wind and rain by sitting down, can raise clouds and fog by standing up, can make rivers and lakes by drawing on the ground, and can create mountains by piling of sand." Each spoke in his turn, the chemist

Huang-ti, the legendary Yellow Emperor, reputed and perhaps mythical founder of alchemy, humbly seeking knowledge of the Tao in the cave of the sage, Kuang-Ch'eng-tzŭ.

among them last. "One of us can boil mud to get gold, assay lead to get silver, and can treat the eight stones to give pearls. He can ride the dragon and harness the clouds to travel afloat on the Great Clearness." Liu An made the medicine but did not take it at once. Later, on being involved in political difficulties, he went up into the mountain with the eight *hsien*. "There they made a great ceremonial offering and buried the gold in the earth. They rose to the sky in broad daylight. The stones on which the eight *hsien* and Liu An had stepped became marked. Even now they are found to have the footprints of men and of horses. Chickens which pecked at the *tings* used in preparing the medicine, and dogs which licked them, attained lightness. The chickens cackle and the dogs bark in the sky."

The *Ts'an T'ung Ch'i* (Akinness of the Trio) of Wei Po-yang is the earliest known text on alchemy. It is one of the Taoist classics and purports to be a commentary on the Book of Change but is really a treatise on the preparation of the pill of immortality. Its author, the "Father of Alchemy", was a native of Wu in the present province of Kiangsu. In the year 121 A.D. he was summoned to court but refused the invitation because he had no liking for officialdom. In the epilogue of the *Ts'an T'ung Ch'i* he describes himself as "a lowly man from the country of Kuai, who has no love for worldly power, glory, fame, or gains, who wastes his days leading a simple, quiet, leisurely, and peaceful life in an unfrequented valley."

The *Lieh Hsien Ch'üan chuan* tells that Wei Po-yang "entered the mountains to make efficacious medicines. With him were three disciples, two of whom he thought were lacking in complete faith. When the medicine was made, he tested them. He said, 'The gold medicine is made but it ought first to be tested on the dog. If no harm comes to the dog, we may then take it ourselves; but if the dog dies of it, we ought not to take it.' . . . . Po-yang fed the medicine to the dog, and the dog died an instantaneous death. Whereupon he said, 'The medicine is not yet done. The dog has died of it. Doesn't this show that the divine light has not been attained? If we take it ourselves, I am afraid we shall go the same way as the dog. What is to be done?' The disciples asked, 'Would you take it yourself, Sir?' To this Po-yang replied, 'I have abandoned the worldly route and forsaken my home to come here. I should be ashamed to return if I could not attain the *hsien*. So, to live without taking the medicine would be just the same as to die of the medicine. I must take it.' With these final words he put the medicine into his mouth and died instantly. On seeing this, one of the disciples said. 'Our teacher was no common person. He took the medicine and died of it. He must have done that with especial intention.' The disciple also took the medicine and died. Then the other two disciples said to one another, 'The purpose of making medicine is to attempt at attaining longevity. Now the taking of this medicine has caused deaths. It would be better not to take the medicine and so be able to live a few decades longer.' They left the mountain together without taking the medicine, intending to get burial supplies for their teacher and their fellow disciple. After the departure of the two disciples, Po-yang revived. He placed some of the well concocted-medicine in the mouth of the disciple and in the mouth of the dog. In a few moments they both revived. He took the disciple, whose name was Yü, and the dog, and went the way of the immortals. By a

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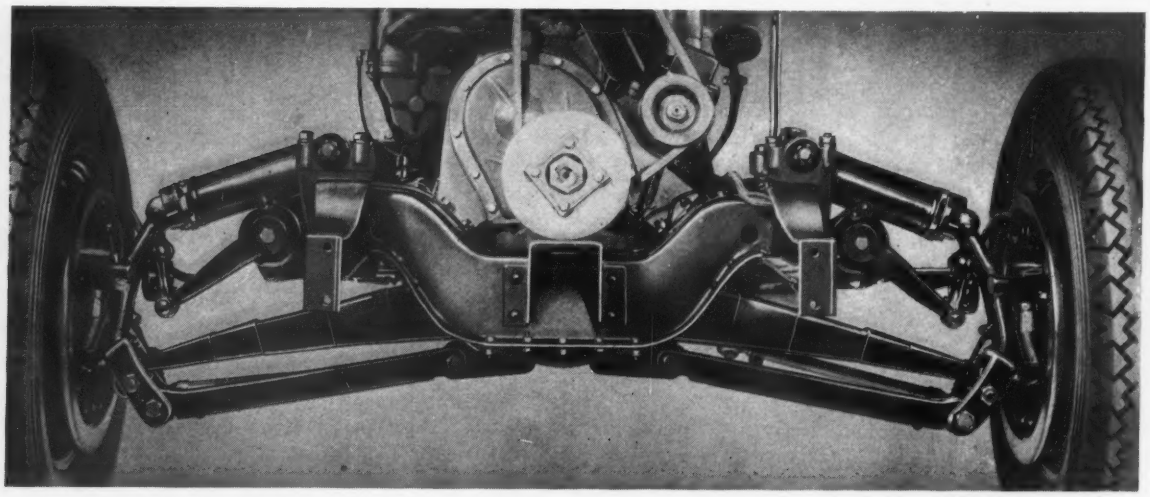
Liu An and one of the Hsien who taught him the art. The barnyard animals, having eaten the materials which remained in the vessels after the preparation of the medicine, also ascended into the clouds.

ENGINEERING FEATURES OF THE 1935 AUTOMOBILE

By S. CURTIS POWELL '37
Massachusetts Institute of Technology

THE new models for 1935 show a great improvement over the 1934 models with greatest emphasis being placed on comfort. Riding ease, good vision, ease of handling, and safety all contribute to make the comfort engineered car. Slight changes have been made in the basic engineering practices, most models showing only a considerable refinement in detail. To the casual observer or to the ordinary person in the market for a new car, the appearance of the new models is most radically changed. And there is no doubt that there has been a definitely increasing use of the streamline motif by the designers. This trend is an advantageous one, although not because of the reduction of wind resistance, but rather because it produces a much more commodious interior, greater structural strength, and more vision in driving, as well as adding much to the esthetic appeal of the finished vehicle. Economy of operation is another factor which has been taken into consideration by the designers, which probably helps to explain the small changes that have been made in the way of increasing power, and hence pick-up and speed, by the simple expedient of increasing the size of the engine. The increases that have appeared are generally the result of refinements in manifolding and carburization, and increase of compression ratio which, while increasing the power, also decrease the cost of operation. Refinements that add to the life of the automobile are to be found in numerous instances. A less expensive car has been added to several lines that have formerly been associated only with the medium or higher price classes. This change indicates a constantly decreasing market for the higher price machines, because of the economic condition of the country and the greater convenience of the smaller cars in the crowded traffic conditions on the majority of our highways.

Let us first consider the mechanical development that has affected riding comfort. Springing is probably the most important single factor in this consideration. Unless the springs are correctly designed to give the necessary freedom to the wheels, the road shocks will of necessity be transferred to the body of the vehicle, and thence to the passengers. In the past, because of difficulties in producing a steel that would give the proper springing qualities and at the same time have sufficient strength to support and keep in alignment the various members of the chassis, the springing rates were much too high, and there was also a distinct difference in the rates for front and rear springs. Last year individual wheel suspension was first introduced on American cars. According to the manufacturers and sales managers, this radical development, which has been used for several years in Europe, would end forever all pitching and bumping on the back seats of their respective products. There is no question but that the primary object, a smooth ride, was attained. But there were a good many defects in the systems. One needed only to drive one of these cars at high speeds to realize that they lacked a certain degree of stability. The designers were not satisfied and this year several manufacturers abandoned the system. Leaf springs (the conventional type) have a certain damping effect due to frictional contacts between the leaves. With the coil



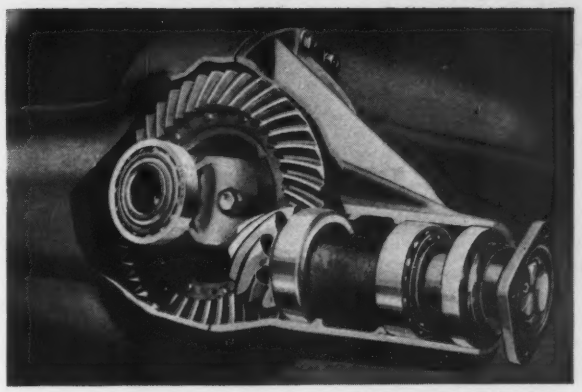
Automotive Industries

Unique independent suspension employing a transverse leaf spring.

spring there could be no inherent damping effect; therefore this damping was supplied by shock absorbers of various types. If something went wrong with these devices, the motion of the individually sprung car became well nigh continuous, as there was no force acting to kill the vibrations set up when the wheels passed over a bump. One of the new arrangements that appeared this year makes use of a single leaf spring mounted transversely, as on a certain popular car, but with each wheel supported on separate links. This innovation gives, in effect, an independent suspension, yet retains the good qualities of the conventional system. With the wheels held in alignment by other means, the springs can be soft enough to give the desired riding quality, and with the particular arrangement mentioned, the car handles perfectly, being steady and easily manoeuverable at high speeds. In another type new developments in metallurgy have been used to produce springs that give good riding quality, yet are able to perform the function of holding the wheels in place. An interesting use of the torsion rod type of sway eliminator is found in conjunction with these types; that is, it is mounted on the front of the chassis instead of in the customary position at the rear. Several other cars are being offered with optional equipment of individual suspension, rather than as a standard part of the car. Even those cars which have not made any very apparent changes in their design have greatly improved the quality of their ride until it compares very favorably with the independent systems. A general slowing down of rates and a syncopation of front and rear spring periods has accomplished that which the independent system was expected to do. It is certainly a tribute to the designers that, even after so short a period of development, those models which are continuing the individual systems may be bought with perfect confidence in their dependability.

Experimental work is still being pushed forward and probably next year will reveal new developments along these lines. The Leaf Spring Institute, the code authority for the leaf spring manufacturers, has done considerable investigating and has finally announced to the trade a new type chassis. The most radical points about it are a single tubular longitudinal member in the frame and the individual suspension of all four wheels, which is accomplished by using two transverse leaf springs of exceptional smoothness over each axle. A car has been actually built with these features and has been proven, according to reports, to live up to all the expectations of the designers.

Another very general trend is the practice of moving the major weights farther forward so as to make more nearly equal the distribution of mass. This change seems greatly to slow down the period of oscillation. It has been rumored that standard production, rear-engined cars would soon make their appearance on our highways. Again the European designers have been a jump ahead of the Americans, although some of our manufacturers have carried on experimentation in this direction. The weight distribution made possible by placing the engine in the rear is also said to improve riding quality.



Automotive Industries

Hypoid rear axle which brings the drive shaft below the floor and eliminates the tunnel often used.

Other factors which add to the comfort of the passengers are of minor importance. Seat angles and heights have been changed. Deeper cushions have been provided. More efficient insulation of the body interior from engine heat and atmospheric conditions is marked on some models. Wider doors provide easier egress and entrance. As has been mentioned, the new body contours allow increased seat width so that six passenger sedans are a reality. Therefore, the position of the motor allows a "between the wheels" ride which everyone knows is more comfortable than the old position out over the rear axle. A rear engined car should make this feature very prominent.

So much for the passenger comfort in a physical sense. The driver in the 1935 cars will find much to catch his fancy as well as to give him a sense of safety never before obtained. All kinds of automatic devices are provided. Perhaps the most interesting advance in an engineering way is the electro-vacuum shift which is available on certain makes. Unlike a self-shifting transmission which was introduced several years ago, this electro-vacuum shift is operated manually. A small lever projects from the steering wheel post within easy reach of the driver's fingers as he rests his hand on the wheel. Shifting is done in the conventional manner on this miniature lever. Or, if the driver so desires, he may shift on this lever while the car is remaining in gear but the actual change of gears will not take place until the clutch is depressed, or, in the case of automatic clutch, until the accelerator pedal is released. No gear shift lever is present to clutter up the front compartment. The greatest advantage, however, seems to be its use as a "pre-selection" device. As one approaches a light or other traffic condition where the possibility of having to slow down considerably is present, the driver "pre-selects" a lower gear. If it is found that the anticipated deceleration is unnecessary the driver continues in high gear. If he finds it necessary to slow down considerably it is necessary only to depress the clutch in order to perform the shift to a lower gear, making the pick-up of the lower gear instantly available without taking the hands from the wheel or the eyes from the roadway at a time when dexterous handling is

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PROTECTING YOUR EYES

With Scientific Illumination

By PARRY H. MOON '27
Assistant Professor of Electrical Engineering
Massachusetts Institute of Technology

NEARLY everyone will tell you that he experiences more eye strain at night, and would rather do drafting or other close work in the daytime — why? Is it not because our artificial lighting is still done in the spirit of the middle ages? We have become accustomed to lighting our rooms and our desks in certain ways which have been handed down from generation to generation,, and we continue to use these methods (merely replacing the candle by the oil lamp, the oil lamp by the electric lamp) without any attempt at logical design.

Take your study room for instance. The general illumination is probably provided by a distant electric globe mounted in a fixture which was designed, apparently, when knighthood was in flower, and which has the sickly appearance and effectiveness of a tallow candle. A few trials at studying under such lighting has convinced you of its inadequacy, and a desk lamp is obtained—probably one of those goose-neck affairs with metal shade, which constitutes one of the most infernal inventions of mankind since the time of the Inquisition. The sense of general gloom is now emphasized by a glaring spot of light directly beneath the lamp. Into this spot you are expected to move your book, papers, and slide rule. Actual test shows that the illumination of the book may be more than ten times that of the nearby papers. The eyes, of course, tend to adapt themselves to either illumination, but since this adaptation process, which is a complex photochemical one occurring in the retina, is inherently rather slow, the eyes will generally not be adapted to either value of illumination and there will be a sense of eye strain. Under such conditions glare due to reflected light is also very difficult to eliminate.

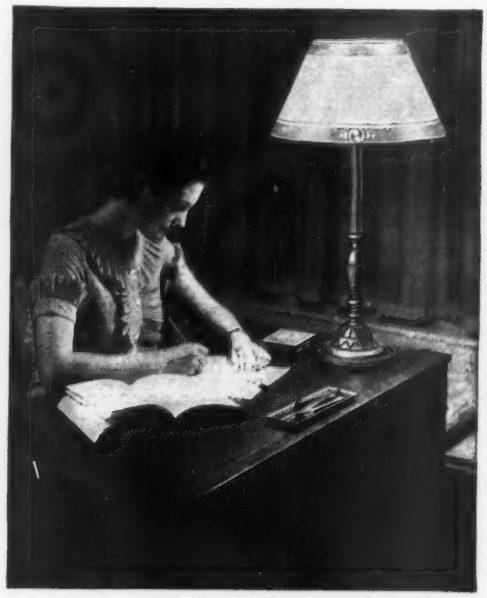
Let us, therefore, forget what we have used in the past and what others have used—whatever it is, it is probably wrong. Let us attack the problem of lighting your desk as we would approach any other engineering problem. Certainly enough time is spent at that desk to repay a few minutes' study of the problem. Evidently the requisites are something like this:

1. Adequate illumination of the entire desk.
2. Satisfactory illumination of the surroundings.
3. Entire absence of direct glare from light sources.
4. Absence of glare due to reflected light.
5. Absence of troublesome shadows.

Before studying the above items in detail, a short digression is necessary regarding nomenclature. Illuminating engineers talk a great deal about *luminous flux* and think of the light source as sending out a great bundle of luminous flux, just as a charged sphere is conceived to have associated with it an electrostatic flux. The unit of luminous flux is the *lumen,* and the number of lumens falling on the desk per unit area is called the *illumination* of the desk. It is expressed in lumens per square centimeter or lumens per square foot.* The first question is, then, what is adequate illumination and, to be specific, how many lumens per square foot do we need on the desk surface? A large amount of research has been performed on this subject, and

* Often erroneously called the "foot-candle".

The camera, even better than the eye, catches the differences in illumination. The correct way, shown on the right, is an obvious improvement over the old-fashioned method, shown on the left.



All Illustrations Courtesy of General Electric Co.

the results indicate that for reading or doing similar work with black on white paper, the illumination should be between 10 and 100 lumens per square foot. People who are nearsighted, those with astigmatism, and elderly people, generally need more illumination than those with normal eyes. The present feeling seems to be that 10 is too low a limit for reading, and it is significant that the best recent installations in offices and drafting rooms give in the neighborhood of 30 lumens per square foot with a tendency to go to even higher values, such as we commonly get when near a window in the daytime.

As a matter of interest, a table of average illumination values, as obtained at Massachusetts Institute of Technology, is given below. The table presents a rough picture of the values ordinarily obtained and allows one to visualize to some extent the recommended levels of illumination. For one thing, this table should kill that bugaboo of "too much light." The average person is obsessed with a vague fear that dire punishment will result from using "too much light"—say eight or ten lumens per square foot! True, we do not care to study in direct sunlight with its illumination of the order of 10,000 lumens per square foot, but most people have no objection to reading outdoors in the shade with 1600 lumens per square foot or inside near a window with 100 lumens per square foot. The trouble is that glare has been present in practically all artificial installations. Increasing the size of lamp has increased the glare and has more than offset the beneficial effect of higher illumination. With lighting which is correctly designed, glare does not exist. Thus, if one is very careful in the placing and the shielding of lamps, he will find that higher levels of illumination are distinctly helpful. Apparently there is no danger connected with the adequate illumination of the desk, except perhaps that associated with an irate landlady who has just received the electric bill.

Average Values of Illumination

	Lumens per square foot
Desk in direct noon sunlight, summer	11,000
Desk in shade — clear sky, summer	2,900
Desk in shade — clear sky, winter	1,600
Desk in shade — overcast sky	900
Modern hospital operating rooms, artificial light	1,500
Desk in room near window (M.I.T. offices), daylight	50-100
Modern practice in drafting rooms, etc., artificial light	30
Illumination from I. E. S. (Illuminating Engineering Society) Study Lamp — under lamp	40
Study Lamp — 2 ft. from lamp	10
Eastman lecture room, 6-120	7
M. I. T. offices, artificial light, no desk lamps	4-7
Modern practice for corridors	5
M. I. T. Central Library — reading room tables	2
M. I. T. Central Library — stack tables	2
M. I. T. corridors	0.4

The second requirement is satisfactory illumination of the surroundings. While it is true that a concentrated illumination of the desk, with the remainder of the room practically unlighted, tends to promote mental concentration, most lighting experts feel that too great contrast is conducive to eye strain. With the illumination of the room walls less than that of the desk, but not too much less, one can rest the eyes by focusing them occasionally on a more distant object; which cannot be done satisfactorily if too great a difference in brightness exists. A ratio of 10:1 is generally regarded as the maximum allowable.

The general study lamp as developed by the Illuminating Engineering Society.

The third point—absence of direct glare—is obviously necessary, and requires no comment. Likewise, the elimination of images of the light source formed in polished metal or glass objects which may be in the field of view is very essential to correct illumination. But reflected glare is a far more insidious danger than would be imagined, and one which is almost universally overlooked. It is, I believe, the most prevalent cause of eye strain and the principal reason why fine work is more difficult at night than under natural light. As the result of observations made here during the past two years, I have come to the conclusion that *if the replacement of desk surface, book, papers, and other objects by mirrors produces glare, then the lighting is not ideal.* True, by using a dark blotting paper on the desk and books without glossy paper, the defect in the lighting system is minimized until most observers would say it is non-existent. Nevertheless, if one tries the experiment of placing his desk

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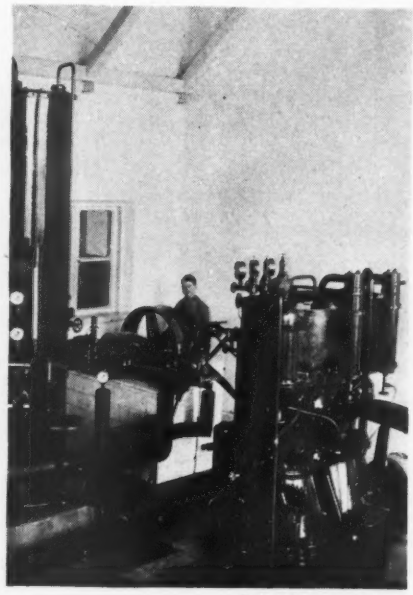
Scientists Approach

ABSOLUTE ZERO

In Recent Experiments

By JAMES B. HESS '38
Massachusetts Institute of Technology

WHILE Commander Byrd and his expedition shiver and freeze in a temperature that frequently reaches 70 degrees below zero, scientists have been attempting to produce in their laboratories the almost inconceivably lower temperature of —495.4 degrees Fahrenheit, which is, they believe, the "absolute zero of temperature" (the point at which all molecular motion ceases). A record approach to this point was made recently by Professor W. J. de Haas, of the University of Leyden, Holland, when he reached a temperature within 0.09 degrees Fahrenheit of absolute zero. His achievement is important because this point is fourteen times lower than the previous "low" of 494.1 degrees Fahrenheit (1.26 degrees Fahrenheit above absolute zero) which Keesom, Professor of Experimental Physics at the University of Leyden, reached in 1929.



Scientific American

A low temperature laboratory in Soviet Russia.

Since absolute zero has never been reached—and some scientists even say that it never can be reached—any discussion on the subject of absolute zero must concern itself with accounts of the methods and apparatus used to reach such unprecedented "lows" and with the consequent problems that attend such attempts. The exact value of the absolute zero has not yet been established, and, although the first three figures (—273 degrees Centigrade) are probably correct, the decimal figures are constantly changed as new information is gathered which allows the calculations to be made more accurately.

Because the Fahrenheit scale is not used in measuring temperatures in scientific work, "absolute zero" is more familiar when given on the Centigrade scale—its value being approximately —273.25 degrees Centigrade. The Centigrade, or scientific, scale divides the range from the freezing point of water (32 degrees Fahrenheit) to the boiling point of that liquid (212 degrees Fahrenheit) into 100 equal divisions, or degrees. On the Centigrade scale each degree is equal to one and four-fifths Fahrenheit degrees, and the freezing point of water is chosen as the zero point (0 degrees Centigrade).

During the eighteenth century, however, scientists noticed that, while all matter expands when it is heated, all gases expand at exactly the same rate. This rate, which was called the coefficient of expansion, was found to be 0.366 for each degree Centigrade. In the light of this fact, Sir William Thomson (Lord Kelvin) suggested an "absolute temperature scale": "If 0.366 be accepted as the expansion coefficient of air, at —273 degrees Centigrade the volume of the air would be reduced to zero." Therefore the absolute temperature scale, with degrees the same size as those on the Centigrade scale and with its zero point at —273 degrees Centigrade, was given the name Kelvin scale in his honor.

In order to study temperatures, scientists had to invent an instrument for measuring temperature changes. Galileo made the first instrument for this purpose and called it a thermometer. It was merely an air-filled glass tube which was closed at one end and had its open end inverted in a pan of water. When it was placed near a hot object, the air expanded and some of it was forced to escape; then, when the air cooled to its original temperature, an amount of water proportional to the temperature of the hot body was sucked into the tube.

Sanctorio, a contemporary of Galileo, was the first to use "fixed points" in graduating his thermometer. He selected the temperature of snow and the heat of a candle as his "fixed points". The first sealed thermometer was made by Ferdinand II, Grand Duke of Tuscany, about 1654. In England, Robert Boyle, at the request of the Royal Society, made experiments on the thermometer about 1664, his "Lectures on Cold" being published in 1665. The mercury thermometer appears to have been first employed in 1657 by the Accademia del Cimento of Florence.

Fahrenheit, of Dantzig, made some great improvements on this type about 1706. In 1714 he constructed the thermometer which bears his name, using three fixed points for the division of the scale. He arrived at a zero by using a mixture of ice water and sal-ammoniac. He made the selection of this mixture because it produced the lowest temperature known at that time, and, by taking the lowest temperature as zero he hoped to escape the necessity of using negative temperatures. His second point he obtained by taking

a mixture of ice and water—this point he called 32 degrees or freezing point. The third mark, or blood heat, he obtained by placing the thermometer in the mouth or in the armpit of a healthy man and holding it there until it acquired the temperature of the body. He then divided the distance between the melting points of ice (32°) and the boiling point of water (212°) into 180 degrees, this number being half the number of degrees in a circle.

Professor Celsius of Upsala, and Reaumme in France, invented scales which are in use at the present time. Celsius suggested the Centigrade scale which has already been discussed, while Reaumme's scale enjoys popularity among the non-scientific people in Germany and Russia. Reaumme's scale has only 80 divisions between the boiling and the freezing point of water.

The present-day thermometer consists of a sealed, evacuated glass tube with a bulb at one end; the bulb contains a liquid which expands with heat and rises up the glass tube, on which a suitable scale has been etched. Thermometers of this type, however, have certain limitations in the laboratory. The glass tube expands at the same time that the liquid does, and so the volume of the tube is increased and the liquid does not rise to the correct height. Also, liquids freeze when the temperature is low. Therefore, certain other thermometers have been developed for the laboratory.

The platinum thermometer, invented by Sir W. Siemens, is accurate between the temperatures of —190 degrees Centigrade and 660 degrees Centigrade. The resistance which platinum offers to the passage of an electric current decreases as the temperature falls, and so the temperature can be determined by measuring the conductivity of a platinum wire of a specified size.

Another instrument uses the fact that the pressure of a confined volume of a gas decreases with the temperature. This instrument, called the "gas thermometer", measures the pressure on a volume of a confined gas such as hydrogen. When corrections have been made for the properties of the individual gas, the temperature can be easily calculated. If the gas is highly rarefied, its properties seem to approach those of a "perfect gas", that is, a gas which has no special individual properties and therefore follows the pressure-temperature-volume law exactly. With such an instrument it is possible to measure temperatures that approach the lowest points known. Just such a "perfect gas" is used in determining the correct value of the absolute zero, and as the "perfection" of the gas is dependent upon its rarefication, the computed value of the absolute zero is constantly changed as scientists find means of producing and studying higher and higher rarefications.

Scientists have been trying to reach the absolute zero ever since they decided that it must exist. At the time of Fahrenheit (1714) the lowest known temperature was 0 degrees Fahrenheit. Faraday (1840) reached —105 degrees Centigrade in an attempt to liquefy oxygen. Fifty years later, scientists had produced temperatures of about 12 degrees above absolute zero. Onnes, the Dutch physicist who first succeeded in liquefying helium, attained 0.82 degrees. Kelvin and finally Keesom pushed the minimum down to 0.7 degrees Kelvin in 1929. Now, during the past year, de Haas carried on experiments in which he reached temperatures within one-twentieth of a degree of absolute zero.

Almost hand-in-hand with attempts to reach the absolute zero have been the attempts to liquefy helium gas and, finally, to solidify it. The gas has the lowest boiling point of all gases. Onnes cooled the liquid to —272.18 degrees Centigrade and expressed the belief that it remained liquid even at absolute zero under normal pressure. In June, 1926, Keesom succeeded in producing solidification at —271.9 degrees Centigrade under a pressure of 26 atmospheres.

During the past year, Professor Peter Kapitza, the director of the Royal Society Mond Laboratory at Cambridge, in England, invented a new type of machine for liquefying helium. His machine produces larger quantities of liquid helium with greater ease and less expense than was previously possible, so that large quantities of liquid helium will soon be within the reach of anyone who makes a replica of this machine. The practical differences between large and small quantities of liquid helium may be appreciated when it is learned that some research workers, whose work would be impossible without liquid helium, have never seen liquid helium because in all their experiments they have produced the helium inside metal tubes, through which it is not visible to the eyes. Their knowledge of its existence depends entirely on the observation of its effects and not on the liquid itself. Therefore, one advantage of preparing liquid helium in large amounts is that it can be handled in glass apparatus and thus allow direct optical observation on its action.

If the helium gas is first cooled to the temperature of liquid nitrogen, Kapitza's machine will, after about 25 minutes' working, begin to liquefy helium at the rate of about two liters, or two quarts, per hour. About one and a half liters of liquid air are used in the preparation of each liter of liquid helium. This is only a minimum performance, and in the future the rate of production will be considerably increased. But compared to the original method, this process is wonderful indeed, for the older method required the consumption of five liters of liquid hydrogen in addition to six liters of liquid air for the production of one liter of liquid helium.

Kapitza's apparatus used the principle of the reciprocating engine, which, hitherto, would not work below the temperature of liquid air, which is about one hundred degrees above absolute zero. The difficulty of making a reciprocating engine work at a low temperature is familiar. The lubricating oil thickens and causes the piston to stick to walls of the cylinder. Claude, who devised a method of extracting argon from the air, made a reciprocating engine work at the temperature of liquid air by using liquid air as the lubricant. But the same principle would not work if liquid hydrogen or liquid helium were used, and so Kapitza made a reciprocating liquefier work without lubrication.

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EDITORIALS

WASTING INVESTMENT

MORE than half a million dollars has been invested to provide Technology men with one of the outstanding engineering and scientific libraries in the country. Yet, this library is not available to a great many of the students because its doors are locked for more than two-thirds of the week.

Of what value is the library to the student when it is open during the hours when he must attend his classes? False economy has caused the Institute to close the library at six o'clock on weekdays; Saturday evening and Sunday, the logical time for reference work, is excluded by the Administration's edict. For many students evenings and the week-end are the only hours free from laboratory and class conflicts.

As in the case of the telephone, a library is not used at all times, but, when it *is* needed, the value of immediate accessibility far outweighs its cost of maintenance. If the Institute is not financially able to provide a fifteen-dollar-a-week clerk in order to make a half-million dollar investment available to its students, perhaps it would be possible to transfer some of the students working under the F. E. R. A. to this task.

THE WORLD COURT

THE recent decision of the Senate against the entry of the United States into the World Court again brings into prominence the question of international co-operation. That such co-operation is becoming increasingly essential is evidenced by the tangle of inter-relations between nations in commerce and industry to mention only the most obvious testimony. It is becoming more and more imperative that international misunderstandings resulting in economic or military strife must cease.

One method of eliminating such misunderstandings is the idealistic approach as expressed in the formation of the League of Nations and the World Court. An idealistic approach, however, seems to be a most illogical choice in the face of the present-day skepticism and lack of ideals. Considered from the United States' point of view, the World

Court does not appear to offer any more substantial hope of world peace than the present impotent League of Nations. There is nothing to indicate that in either the World Court or the League there will not be a recurrence of Japan's treatment of the League and the League's subsequent lack of action. That lack of action was, in part, a reflection of the apathy of nations in general to international considerations, but it was even more the consequence of national selfishness and fear. But selfishness and fear are basic human traits and their true elimination can be accomplished by a complete transformation of human character—a remote if not fantastic possibility.

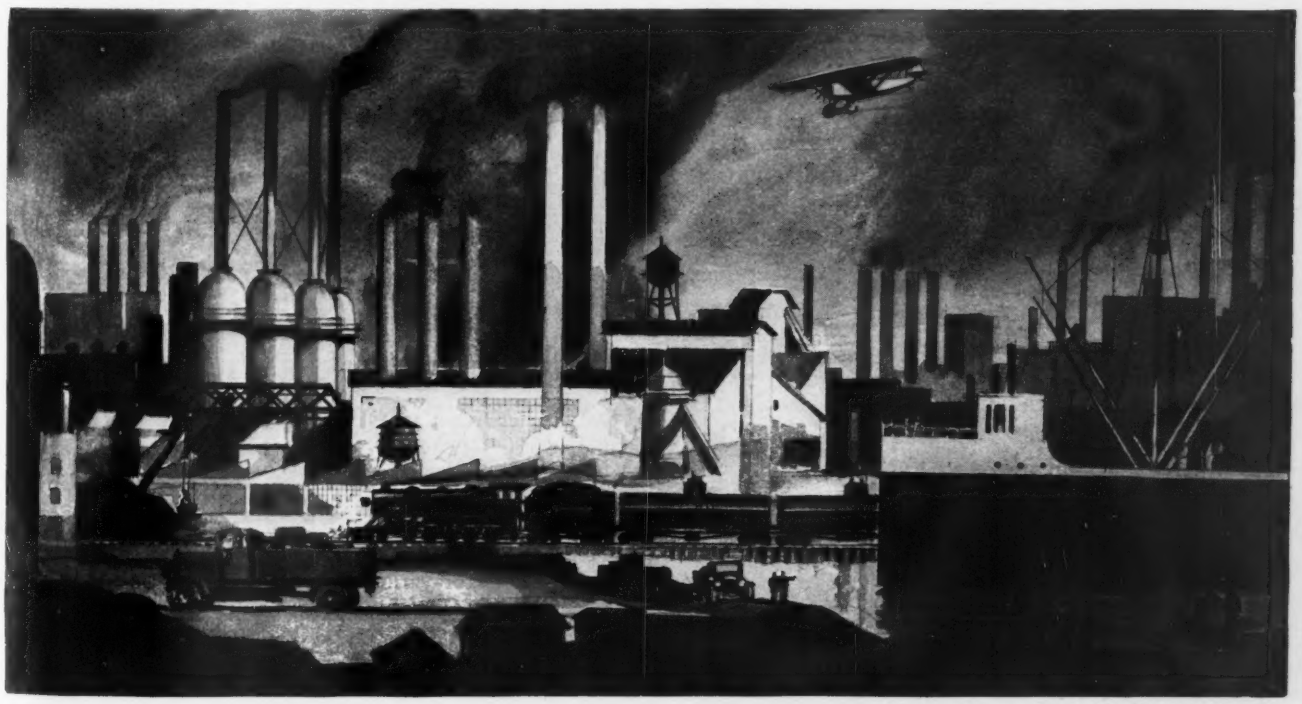
If one accepts the present and probably long-continued existence of selfishness and fear, a solution of international problems is much more readily obtainable by circumventing those traits than by attempting to eradicate them. If, for example, the speed of transportation is increased to the point that the entire world is bound very closely together in a time sense, if international relations are thus increased in intimacy, the uselessness and suicidal nature of war will be made so clearly apparent that men will be forced to have world peace to secure their own individual preservation. Such an intimacy would break down the barriers of tradition and patriotic pride that separate nations. Selfishness and fear would still be present, and would, in fact, be the prime movers of thought and action, but they would be subjugated to the yoke of co-operation.

NO LIGHTS

CONTROL regulates direction and speed. The Macon crashed into the sea when control was lost. Likewise our vehicle of state may come to grief if regulation is not fixed in one group. Our vehicle has motive power and brakes, but the brakes are locked and the clutch is slipping. Even though the engine is racing from constant government priming; however, we are not moving. Government control of industry or private initiative—which is in the driver's seat? Obviously neither has sufficient control to get the vehicle under way. We are straddling and hedging attempting to get the best from each system, and, meanwhile, as our vehicle jumps and hops forward in occasional spasms when the priming is strong enough to roll it on and drag the brakes, the proponents of government control and those of private initiative are so occupied with the engine and brakes that neither thinks to turn on the lights and try to steer.

Dark depression reigns and in this chaos policy is not determined and our vehicle hits many obstacles. That which might be constructive becomes destructive. Farmers are paid not to raise products; commodities are sold at sacrifice prices to other countries to maintain price, and then these same commodities are required to feed the hungry. Cities can not obtain sufficient men to remove snow—they are on the welfare—in effect being paid not to work. Factories which are ideal sites for future industries are being demolished giving weight to the argument that real estate taxes be levied only on properties which are earning an income.

While the two agencies struggle for *control* we must sit back and wait for daylight though the unlighted darkness hints that there will be eternal night, and we must pray that one will gain the upper hand for then the lights will be turned on and steering will commence again, and policy will no longer be blurred and conflicting. To attain prosperity and safety control must remand to one of the two systems. Either government control must dominate or private control must return to power.



The DuPont Magazine

ENGINEERING DIGEST

HEAVY WATER

SINCE the discovery of heavy hydrogen and oxygen isotopes in 1932 by Urey, Brickwedde, and Murphy, many complications in the study of water have arisen, mainly because heavy water is inert. The terms, suggested by the discoverers, deuterium (D) for heavy hydrogen and protinium for ordinary hydrogen, have gained wide usage today. Most experimenters believe the deuterium nucleus to consist of two neutrons, conceived as primary uncharged particles of mass one, and one positron. Both the heavy hydrogen and, to a certain extent, the heavy oxygen (O^{18}) are concentrated by the commercial electrolysis of water. As the electrolysis proceeds, the density of the residual water increases and is accompanied by a rise in the freezing and boiling points. The viscosity of heavy water is higher and the surface tension lower. The vapor pressures of common and heavy water exhibit a large difference, due probably to the greater strength of the D bond as compared to the H bond.

Chemically, heavy water may be of great importance since chemical reactions having a positive temperature coefficient go about half as fast at ordinary temperatures in heavy water as in common water. An interchange of isotopes has been found to take place when ammonia is dissolved in heavy water.

$$HDO + NH_3 = H_2O + NH_2D$$

This exchange has also been noted with the heavy oxygen isotope:

$$H_2O^{18} + SO^{16}O^{16} = H_2O^{16} + SO^{18}O^{16}$$

Further experiments have shown an equilibrium to be slowly established between heavy water and hydrogen gas or between heavy hydrogen gas and ordinary water.

Biologically, heavy water is of limited importance. Low concentrations of heavy water appear to stimulate growth, while higher concentrations have been shown to retard the cell division of bacteria and, in many cases, to have a lethal influence. However, heavy water is not toxic to any great extent.

All ordinary water contains a small amount of deuterium, estimated at one part in five thousand. Also, there is evidence of a slight variation in the isotopic composition of natural water. Thus, water from the Dead Sea and Great Salt Lake appears slightly denser than ordinary water while sea water is two parts per million heavier. In plants deuterium has been found to be slightly concentrated, willow sap containing 2.9 parts per million more than ordinary water.

A third isotope of hydrogen of mass three, tritium (T), was announced by Latimer and Young (1933). It exists in the ratio of five parts per million in pure heavy water, but has not as yet been concentrated to more than one part in five thousand D, and therefore is of purely scientific importance. (*Quarterly Review of Biology,* vol. 9, no. 3) —H. O. S.

PHOTO-ELECTRIC CELLS

NOVEL uses for photo-electric cells crop up periodically, but the latest batch is said to be unusually interesting. The most important use brought to light this time is the employment of a photo-electric cell as a smoke indicator in smoke stacks. The improvement of this most recent indicator over previous devices of the same nature lies in the fact that no glass windows are necessary in the walls of the chimney, and consequently, there is nothing to get fouled by the smoke.

To use this latest device two small holes are drilled diametrically opposite in the walls of the chimney. The lamp housing is mounted on a bracket outside one hole, and the photo-cell and amplifier are mounted outside the other hole in such a manner that the beam of light from the lamp impinges upon the photo-cell. As soon as smoke impedes the beam of light, a relay in the amplifier closes, and brings into action an alarm, which may be one of several forms. The cover of the amplifier is equipped with an iris diaphragm so that the engineer in charge may set the point at which the alarm will go into action.

The alarm may consist of a bell and two lights, one green and one red. When little smoke is passing up the stack, the green light will be lit. However, if the amount of smoke passing up the chimney is greater than the maximum setting of the amplifier, the bell will begin to ring, and the red light will flash on. If there were several boilers, there would be one bell for all of them, and a pair of lights for each boiler, so that if the bell rang, the engineer could see at a glance from which boiler the excess smoke was coming.

An apparatus similar to the above may also be used in studying the turbidity of sewage. The method may also be applied for sewage treatment operations involving automatic control.

A number of months ago, the Pennsylvania Terminal, in New York City, installed photo-electrically operated doors for the benefit of luggage laden passengers. Now numerous hotels and restaurants have installed similar self-opening doors between kitchens and dining rooms. As the waiter walks through a light beam, the door jumps open.

The operation of photo-electric cells in many fields, such as counting, color matching, weighing, color testing, and the operating of various devices has been improved by the introduction of new tubes and of quicker operating relays. These more sensitive devices will probably be put to many novel uses before very long. (*Electronics,* December, 1934) —F. B. K.

RESEARCH IN REVIEW

COURSE I — Civil Engineering

THE civil engineering department is including in its activities explorations into the scientific fundamentals underlying the behavior of cement and clay materials. Engineers generally have been content to take cement and clay as they are and to attempt to learn as much as possible about their behavior in the field and laboratory without inquiring into the physics and chemistry responsible for these behaviors. Already, the materials research division of the civil engineering department is finding that through consulting and sharing research with the departments of chemical engineering and geology, many mysterious behaviors of these materials are becoming less mysterious.

Without losing sight of the importance of crystal development and occurrence, gelation appears to be fundamental to the properties of both cement and clay. Going deeper, the gelation appears to be related to surface phenomena of the particles of cement and clay, especially the magnitude, sign, and distribution of electric fields of force on the surfaces of particles. In fact, it may be that in the cement grain, relatively enormous interior surface areas, actually within the outer boundaries of each particle, must be considered to explain the properties of hydrating cement.

While there seems to be little connection between the economy and safety of structures on the one side and fields of force on particles one ten thousandth of an inch in diameter on the other side, when viewed through the eye of the chemical engineer, the connection is as apparent as that between glue and furniture. The civil engineer is borrowing the eye of the chemical engineer and co-operating with him and with the geologist in making his fundamental explorations. The growth and movement of particles, the development and change in structure of the gel and crystals, the heat of hydration, and the fixation of water; these are subjects under investigation at present which are expected to supply the complement to studies of volume change, strength, and durability of concrete as applied to structures. The explorations involve petrographic studies, which require unusual technique because the details of most importance seem to be those which are of submicroscopic size. Unusual technique in chemical analysis is also involved, because, especially in the case of cement, not only are both gel and crystals present but apparently, there are several forms of each. The petrographic and chemical results are expected to show correlation with measurements of the changing rates of heat liberation, volume reduction, and electrical conductivity.

Seminars are being held twice each month for the purpose of bringing together the viewpoints from the different departments. They have been ably guided by Dr. Lewis of the department of chemical engineering.

COURSE VI — Electrical Engineering

Thin Dielectric Films

WE are all familiar with the phenomenon in liquids known as surface tension where a superficial layer of fluid possesses physical properties which differ markedly from those in the remaining liquid. Reasoning by analogy, is it not logical to suppose that an extremely thin film of a diaelectric material might possess electrical properties which differ radically from those of the same material in bulk? To answer this question is the object of one of the investigations undertaken by the Electrical Engineering Department.

To prepare a film, it is only necessary to heat the material in a high vacuum until it vaporizes, and then condense the vapor on a cool highly polished metallic surface. The insulating material—for example, quartz—to be evaporated is placed in a tiny crucible and the latter heated by bombardment with a stream of electrons emitted from a tungsten filament. Even such a refractory substance as carbon can be sublimed at 3500 degrees centigrade by this method. The thin film deposited on the polished metal plate is then covered with a layer of copper in the same manner. The two metallic surfaces separated by the film 10^{-5} to 10^{-7} inches thick constitute a condenser on which electrical tests can be made.

Since films of any solid substance which does not decompose or react chemically with the crucible at the high temperatures can be produced readily, the procedure is adaptable to studies in photoelectricity, rectifying action, and the production of high capacity condensers. For the physicist, the structure of the films can be studied by X-ray and electron diffraction methods. And for the chemist interested in refractories, it is a method for investigating chemical reactions at very high temperatures.

Change in Wave Form of Intense Sound Waves

A study is being carried on to determine the nature and cause of the changes which take place in the form of sound waves of high intensity radiated from a small source such as exists in the throat of a loudspeaker horn or a fog signal. To date, quite astounding changes have been found; for example, with approximately 70 watts of sound power at 120 cps, corresponding to a sound pressure at the source of 10 per cent of atmospheric, a change in second harmonic content of 40 per cent takes place inside the first wave length.

The measurements have been made on a specially designed source, operated directly from the 60-cycle mains. The measurements of sound pressure were made with miniature condenser transmitters developed for the purpose in the Sound Measurements Laboratory, and have been supplemented by motion pictures of the actual air motion at the throat of the unit taken with the aid of Professor Edgerton's well-known equipment and some smoke-screen chemical.

ABSOLUTE ZERO

Continued from Page 11

Gases are cooled and liquefied by the use of two entirely different principles, which are best illustrated by considering the properties of a gas. A gas consists of an enormous number of molecules flying about at a high rate of speed. (In ordinary air the speed is about 500 yards a second.) The energy of motion of the molecule is proportional to the square of its speed, and since the energy of motion is the same as the heat of the molecules, their heat, or temperature, is proportional to the square of their speed. Since the temperature means the absolute temperature, at absolute zero the molecules would have no heat energy and therefore no motion. Hence the temperature of a gas is reduced by reducing the average speed of the molecules.

The speed of the molecules can be reduced by putting some heavy movable obstacle in their path so that they may hit the obstacle and transfer some of their energy of motion to it. Convenient obstacles for this purpose are the blades of a turbine or the piston of a reciprocating engine. If, now, the gas in a tank under a high pressure is allowed to flow to a tank containing a vacuum, and an engine is fixed at the entrance to the vacuum tank so that some of the energy of motion is given to the piston of the engine, the temperature of the gas is lowered. In the same way that a billiard ball loses speed after impact, a molecule loses its energy of motion when it hits a movable object. Since the piston can effect very large reduction in the energy of motion of gas molecules, this method is very efficient.

Although the reciprocating engine has a high efficiency, certain difficulties appear when it is used at a low temperature. As already stated, the pistons freeze up, and the metal of the reciprocating parts tends to become brittle and fly to pieces when the motor is run. Therefore Kapitza had to pay special attention to the design and the properties of the materials he used in the construction.

Until recently, low temperatures were obtained by the use of the other principle. Gas molecules have a slight mutual attraction for each other. When the average distance between the molecules is increased, a little energy is consumed in overcoming this mutual attraction. This energy is taken from the energy of motion, or heat, of the gas. Thomson (Lord Kelvin) and Joule, the physicist who determined the quantitative relation between electric, mechanical and heat energy, discovered the slight fall in temperature when the molecules of a gas are forced to assume greater distances from each other. As this cooling effect is due merely to the increase of the average distance between the molecules, no moving parts are necessary.

In cooling machines based on the Joule-Thomson effect, the gas is highly compressed and the heat produced by the compression is removed by a cold-water circulating system. When the gas, now at high pressure and room temperature, is allowed to expand through a fine nozzle, it is cooled slightly as it issues. The slightly cooled gas is sent around the tube conducting the fresh lot of compressed gas to the nozzle and pre-cools it. When this pre-cooled gas expands, its temperature is lower than that of the previous lot because it started at a lower temperature. In this manner the temperature of the gas can be steadily forced downward.

Although the machines using the Joule-Thomson effect are very inefficient at relatively high temperatures, their efficiency increases considerably at low temperatures, even in comparison with reciprocative engines. Hence the most efficient method is to cool gases down to within ten degrees of absolute zero by expansion engines and then produce the further cooling by means of the Joule-Thomson effect. This is the plan Kapitza follows.

He solves the lubrication problem by avoiding the necessity for lubrication. He arranges that there should be a clearance between the walls of the cylinder and the piston. Then he makes the piston move so rapidly on the expansion stroke that the expansion is completed before the gas has a chance to leak away.

The apparatus which de Haas used in his approach to absolute zero is an outgrowth of the phenomenon which Clark the Scottish chemist, witnessed several years ago. In his experiment, a small tube containing cerium flouride was suspended in an evacuated enclosure immersed in liquid helium at 1.26 degrees Kelvin. A magnetic field of 30 kilogauss was suddenly reduced to 2.5 kilogauss, and the magnetic moment of the salt was measured with respect to time. On extrapolating the susceptibility beyond the region for liquid helium (4 degrees to 1.3 degrees Kelvin), the temperature found was below 0.27 degrees Kelvin. Other measurements gave a value below 0.18 degrees Kelvin. The lowest temperature reached by reducing the saturation pressure of liquid helium was 0.82 degrees Kelvin.

Low temperature research has a greater value than appears at first. The separation of gases by boiling at low temperatures is already an industry necessary for the production of explosives. Other products obtained in the process are pure oxygen for oxy-hydrogen and oxy-acetylene blowtorches, and for respiratory and anesthetic use, pure nitrogen for the production of nitrogen-fixed fertilizers, argon, used in filling some electric light bulbs, and neon, krypton, and xenon, for luminous signs.

The greatest application of the future will probably be in the field of super-conductivity. For instance, in a copper sulfide rod at 1.55 degrees Kelvin, there is no measurable resistance. Tantalum becomes a super-conductor at 4.2 degrees Kelvin. Metals which are alloyed with bismuth, antimony, arsenic, and phosphorus become super-conductors at temperatures considerably higher than the pure metal itself. It is altogether possible that in the future scientists may discover an alloy which becomes super-conductive at the relatively high temperature of liquid air. There seems to be no limit to the possibilities of electrical engineering if a perfect conductor can be found.

Although this new record approach is so close to absolute zero, the actual conditions prevailing at absolute zero have not yet been discovered, nor do scientists know if they are even being approached. Some scientists, for instance, think that the absolute zero can never be reached. One has said that it can never be reached in a finite time, but since radiation of the heavenly bodies into space has been going on for millions upon millions of years, the temperature of some of them must be close to the absolute zero. Since some substances may become unstable under these conditions, some interesting astronomical possibilities are opened up.

In contrast to an absolute zero of temperature, the point at which the molecules must be at their lowest possible state, if all their energy of motion has been lost, scientists also believe that there is an upper limit to temperature. When the temperature, that is, energy density, is at its maximum, all the atoms become free electrons and nuclei without attached electrons. If the pressure is high enough, a mass will be obtained consisting of protons and electrons without interstices, which is practically an enormous nucleus and cannot be further compressed, cannot admit more quanta, and cannot increase its energy. When in this state the atoms may disintegrate into a flash of energy and thus destroy matter. This theory is a possible explanation of the source of the sun's energy.

PROTECTING YOUR EYES

Continued from Page 9

lamp directly in front of him, he will find after an hour or two of reading, the conditions are not as they should be. The truth is that nearly all surfaces, even the roughest of book papers, have a specular component of reflection and thus act to some extent like mirrors. Thus when the surface is observed at an angle equal to the angle of incidence of the light from the source, the paper appears to take on a certain amount of sheen and the desirable contrast between the black letters and the white paper is lessened.

Thus in designing our lighting system it is imperative that we place the source in such a position as to absolutely eliminate reflected glare. This means that *the lamp must never be placed on the desk in front of the reader and must never hang over the desk.* If a desk lamp is used, there is only one possible place for it, and that is in the extreme left corner of the desk near the reader. Even this position allows glare under some circumstances. If the lamp with its shade is hung from the ceiling or other support, it must be behind the reader and not over the desk. A right-handed person will need his lamp about two feet behind him and about two feet to his left.

The fifth requirement—absence of troublesome shadows—is most easily satisfied when the source is large, as an ordinary window. If all the light comes from a single lamp, with no ceiling reflections, it is difficult to prevent very dense and annoying shadows. For this reason, as well as to provide a sufficient general illumination, it is advisable to allow some of the luminous flux from the lamp to strike the ceiling. One simple way of accomplishing this end is to use the new study lamp, the requirements for which have been carefully worked out by the Illuminating Engineering Society. Such lamps have appeared on the market recently, made by several manufacturers, and will be found highly satisfactory. A 100-watt lamp is used, giving plenty of illumination on the whole desk surface as well as a soft general illumination from light thrown on the ceiling. A floor lamp of similar construction is perhaps even better. It uses a double-filament lamp, one filament rated at 100 watts and the other at 200 watts. Either may be used alone, or both may be operated together to light the entire room. Another style of I. E. S. floor lamp is provided with a single-filament 250-watt lamp.

Naturally the I. E. S. lamps do not constitute the only solutions of the desk-lighting problem. Anyone with a little thought and ingenuity can devise a lighting system which will satisfy the five requirements and which will be excellent from the utilitarian (though perhaps not from the esthetic) standpoint. Totally-indirect lighting, for instance, is always possible, requiring merely a 300-watt lamp and any available pan or urn to conceal the lamp and reflect the light. But don't expect such lighting to be efficient; it isn't. The problem must be faced squarely; a large lamp is absolutely necessary. A more efficient way is to use direct light from a 75 or 100 watt lamp in a metal or glass reflector placed behind and to the left of the student. Additional ceiling illumination may be provided from a concealed lamp on top of a book case or elsewhere. It is evident that there is an infinite number of ways to get satisfactory lighting. It is equally evident that most present installations do not belong to this infinitude.

To summarize, best results will be obtained with desk illumination from 10 to 100 lumens per square foot, a general room illumination of at least 1/10 this amount, and a source of large area placed behind and to the left of the student. It is all a matter of horse sense, coupled with a little knowledge of fundamentals. In fact, the recommendations given above are almost self-evident, though a glance at the lighting in almost any library or reading room, or a consideration of the weird and varied contraptions used in the M. I. T. dormitories, leads me to hope that the foregoing suggestions may be of assistance in making study a little less painful.

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EARLY CHINESE ALCHEMISTS

Continued from Page 5

wood-cutter whom they met, he sent a letter of thanks to the two disciples. The two disciples were filled with regret when they read the letter."

In many respects the *Ts'an T'ung Ch'i* bears a strong resemblance to the later alchemical treatises of the Europeans. The author mentions the obscurity of earlier writers and states that he is making an effort to be clear in spite of his feeling of inferiority and inadequacy for the task. He gives symbolic and imaginative names to many of the substances which are used, and insists upon the necessity for careful and accurate compounding and for a cautious interpretation of the text which, he says, he has intentionally obscured in places. The process which he describes in the following quotation is identical with that which is described in the *Speculum Alchemiae* of Roger Bacon.

"Treatment and mixing will bring about combination and rapid entrance to the scarlet portal. The escape must be firmly blocked. Below plays the dazzling flame, while the Dragon and Tiger keep up a sustained vociferation. The flame at the start should be weak, so as to be controllable, and should be made strong at the end. Close attention and careful watch should be given so as to regulate properly the heat and cold. There are twelve divisions of the cycle. On the completion of the cycle a closer watch should be accorded. As the breath expires, life is ended. Death expels the spirit. The color changes into a purple. Behold! the *huan tan* (Returned Medicine) is obtained. This is then made into pills. These are extremely efficacious, although their individual size is so small that they occupy only the point of a knife or the edge of a spatula. . . .

"The aspirant should study this thoughtfully and thoroughly, viewing it from all angles. A thousand readings will bring out some points, and ten thousand perusals will enable him to see. At last revelation will come to bring him enlightenment. Careful study will open the door to the secrets. Nature's *Tao* (Way) shows no partiality, but reveals to all who are worthy."

Ko Hung (about 281-361 A.D.) was a distinguished Taoist and a voluminous writer on medical subjects and history, and is probably the most outstanding figure in the history of Chinese alchemy. His most important work is the pseudonymous *Pao-p'u-tzŭ* which consists of seventy books or chapters, thirty of them being the *Wai-p'ien* or Outer Chapters which deal with matters of politics and government from the Confucianist point of view, and twenty the *Nei-p'ien* or Inner Chapters which treat of the immortals, alchemy, charms, exorcisms, etc. In the chapter on the Gold Medicine of the *Nei-p'ien,* Ko Hung tells how he learned the secrets of alchemy.

"It was Tso Yüan Fang who, in the midst of profound meditation in the Sky Pillar Mountain, was given volumes of the divine books on the Gold Medicine by some spiritual being. It was then the close of the Han dynasty when the land was rife with disturbances. So he fled across the river to come south with the idea of practicing the *Tao* in some famous mountain. From him my great uncle, Hsien Kung, received the Book of the Supremely Clear Medicine in three volumes, the Book on the Nine Furnace-pot Medicine in one volume, and the Book on the Gold Fluid Medicine in one volume. My great uncle in turn passed the books on to his disciple, Chêng Chün. Chêng was too poor to buy the necessary medicines for the compounding. I had been serving him as a disciple for a long time when we went to the Horse Footstep Mountain. There, at an altar especially erected for the purpose and with an oath, I received the books, some magical formulas, and the Unprinted Magical Formulas. This last book was not known to be in existence until Tso Yüan Fang gave it to my great uncle, who gave it to Chêng Chün, who in turn gave it to me. No other *Tao-shih* ever knew of it. . . . .

"Upon learning the Art one will feel as if he had just come out of a filthy cesspool into the open sea, or left the firefly for the sunlight and moonlight—just as the hearing of peals of thunder makes one feel the insignificance of the roll of the drum, and the sight of a whale makes one feel the smallness of ordinary fish."

Concerning the *tan hua* or Medicine Flowers, Ko Hung says that it "will confer immortality on the eater in seven days. When mixed with black fat and heated in a strong flame, the medicine will soon turn to yellow gold. This may also be obtained by heating two hundred and forty liangs of the medicine with one hundred catties of quick silver. If yellow gold fails to appear, heating should be repeated and then it will certainly be obtained."

Ko Hung was a native of Chü-jung in Kiangsu. As a boy he was devoted to learning, but his family was poor and he was obliged to chop wood in order to earn money for the purchase of writing materials. He rapidly acquired the reputation of a scholar. In the reign of Chin Ch'eng-ti (326-342 A.D.) he was offered various government positions but invariably declined them pleading old age. He heard that Persia produced *tan sha* (cinnabar), which he wished for his experiments, and petitioned for the position of magistrate of Kou-lou, a city near the border of that country. "The Emperor refused at first on the ground that the office was beneath him on account of his attainments, but finally gave his consent when Ko Hung explained that he wanted the office not for fame but for the *tan sha* which was available at the locality of the office. And so Ko Hung started for Kou-lou with his family. On their way they were detained by the Governor of Canton. Here Ko Hung stayed, living in the Lo-fo Mountain where he worked on the compounding of the medicine. Seven years did he spend at the place, leading a leisurely life and writing profusely. . .

"One day Ko Hung addressed a message to the Governor of Canton stating that he would shortly start on a long journey in search of worthy teachers with whom to study. The Governor made haste to pay him a farewell visit. On that very day Ko Hung sat until noon when he died at the age of eighty-one. He appeared only to have gone to sleep. When the Governor arrived he was already dead. Although dead, he looked alive and his body and limbs were soft. Upon being placed in the coffin, the body disappeared leaving the clothing behind it."

The Lo-fo Mountain where Ko Hung lived and wrote and experimented for seven years is near the West Lake in present Hangchow. It is known as Ko's Hill. A visitor may see the well from which the alchemist is supposed to have procured water, and visit a shrine within which his portrait is carved on a stone tablet.

THE 1935 AUTOMOBILE

Continued from Page 7

desired. The actual mechanism of the device is comparatively simple. The little lever makes electric contacts with various solenoids (electro-magnets), each one in turn controlling a valve leading to one of two vacuum cylinders mounted on the transmission, which is of conventional sliding gear type. The electrical circuit is not closed until the clutch is depressed. By opening the various valves, the pistons of the vacuum cylinders are caused to move in such a manner as to shift to the desired gear ratio. The device is practically fool-proof and is quite cheap to manufacture.

Another very noticeable advance has been in the design of the braking systems. More manufacturers have gone over to the hydraulic system. The main reason for this is probably the fact that they are always equalized. The mechanical systems appeal to many who feel that they have a larger factor of safety in that if one connection becomes broken or disconnected, the chances are that only one drum will be put out of effect while with a hydraulic system a leak or other defect will likely disable the whole system. In the mechanical systems there are several equalizers that work remarkably well, and the action of the brakes leaves little to be desired. The addition of power boosters to lower price cars has been noted, while the larger cars are using more power than ever. All the various methods of decelerating the car are keeping pace with the rapid increase of speeds, which of course must be so if we are to continue to enjoy our vehicles. Two interesting sidelights on the continuous effort to keep abreast of the modern need are furnished by the method of adjustment of the brakes and the abandonment of freewheeling. Up to a few years ago the front brakes of a car were of minor importance, the rear drums doing most of the work. Today front shoes are so adjusted that they exert a higher pressure on the drum than the rear; hydraulic cylinders are quite often larger on the front than on the rear. Due to the self-energizing properties of the rear shoes, the front and rear wheels will grab at about the same time if the brakes are jammed on hard, making possible much quicker stops. Freewheeling has been abandoned completely on some models which makes it possible to utilize the braking effect of the engine in slowing down the car. Among minor refinements might be included improvements in cooling ribs on drums, increased area of lining, better materials, full floating cam design, and weatherproofing.

Safety is an important thing to be considered in a motor car. The all-steel bodies have become almost essential in the industry, with less and less amounts of wood. Tops are now stamped out of one single piece of steel, supported by steel frames, and welded together into a superbly strong piece of construction. X, A, T, Box, and other structural details float glibly from every salesman's tongue. Lower centers of gravity give better stability in conjunction with wider treads and several rather unusual construction details. Shatterproof glass is fast becoming standard in all price classes. As mentioned before, vision is greatly improved. Lighting systems have been revamped to give better illumination with less glare. Steering has been made more positive in action, smoother, and easier. In fact, no detail has been left untouched that might help to make the 1935 automobiles the safest ever built.

Economy has become of paramount importance in the last few years and the effect is clearly seen in the engineering of the new models. Many a shining new car boasts of an engine that is truly a thoroughbred. The science of feeding the cylinders with the explosive mixture has progressed to an almost unbelievable point of efficiency. Higher compression ratios get the most out of the modern fuels. Thermostats and heat controls keep the engine at an efficient operating temperature. Forced cooling and oiling, with directed streams playing on the trouble spots such as exhaust valves, together with hard blocks or valve seat inserts, elminate the need for frequent overhauls to grind valves, et cetera. These things also show results in the longevity of the car. On long and fast trips the new overdrives, called by various names according to the make, are a source of great economy. Practically speaking they perform the same function as the fourth speed on earlier models. They differ in that they are usually a separate part of the transmission mechanism, mounted either just in back of the gear shifting box or else are of the planetary type. Automatic in operation, they are arranged to cut in at various speeds ranging from forty to fifty-five miles per hour. The engaging or disengaging takes place when the accelerator pedal is released for an instant. With the car speed remaining constant the engine revolutions are reduced as much as one-third. This reduces gas consumption to a remarkable degree and is really a practical and very desirable attachment for any car.

An interesting speculation may be made on the subject of diesel engines for motor cars. There is no doubt but that an engine of the compression ignition type is much more economical to run than a gasoline motor of comparable horse-power. The fuel is much less expensive to buy and

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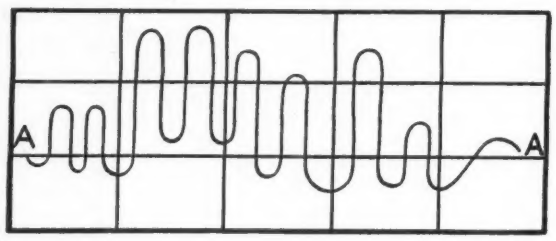
at the same time the consumption, by volume, is less. The fuel oil engine has to operate at high compressions, and is considerably higher in first cost. Even taking this into consideration the ultimate cost of the transportation would be less. The difficulty lies in performance. A diesel motor has much less flexibility than a petrol engine and does not allow the customary standards of pick-up to be maintained. In the estimation of the designers and directors of the large automobile concerns this fact would more than offset the economy to be gained; therefore, little headway has been made in the development of this type. It is possible that the public will become diesel-conscious to the extent that standard diesel automobiles may soon be a reality as they are in Europe where taxes and other conditions combine to make high-powered gasoline cars very unpopular. Diesel trains and trucks have become commonplace and small yachts are now equipped with small diesels that could quite easily be changed to make satisfactory car engines. The idea is not far-fetched, for experimenters have built cars and even raced them with rather surprising results. It is more than likely that some unknown experimenter may be the first to recognize the actual existence of a market for this type of car and make a name for himself and his product by placing it on the market.

In leaving the discussion of appearance until the last, it was not intended to suggest that this was an unimportant feature of the design. In fact it is probably the thing that stands foremost in the minds of most people. In carrying out the streamline effect for their latest offerings, the designers have worked hand in hand with the artists to produce body lines of unusual beauty. Functional design is a term that is used to apply to some of the effects that have been found on the cars of the last couple of years. To an engineer it is said to be always beautiful, but many dispute this, particularly when radical departures are made from the beaten path. As the public becomes accustomed to the rounded contours and simplicity that are a necessary part of this school of design it comes to realize that perhaps those which it thought so ugly are after all things of beauty. Although the distinct streamline motif has been increasingly used, it has not brought forth the adverse comments that were current event a few months ago. Windshields are sloped at greater angles, and most of the cars now have the rear quarters sloped at various angles. If the present pace is continued, and it may well be done, next year will see this year's cars noted as old timers as they pass down the street behind a shiny new 1936 model.



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FRED A. MUSCHENHEIM

ENGINEERING DIGEST

Continued from Page 14

ALUMINUM CAP

"THE crown jewel of the aluminum industry is the cap of the Washington Monument" for the 555 foot tower is surmounted by an aluminum pyramid which was set in place at the final dedication in 1884.

At the time of the casting of the cap in 1884, aluminum was an expensive metal costing $1.10 an ounce. Today it may be had for 21 cents a pound. Furthermore, the cap was the largest piece of aluminum that had been cast until that time.

The use of an aluminum cap was suggested by the chief engineer, Col. Casey, in charge of the monument s construction, but he was afraid that the cap would be prohibitively expensive since France seemed to be the only place where it could be purchased. A Col. Frishmuth, however, offered to cast the 100 ounce piece in Philadelphia and after some price haggling received $225 for the work.

The metal of the cap came from South Carolina corundum and was probably made by the Sainte-Claire Deville process (invented in 1854) in which aluminum-sodium chloride, fluorspar, and ingot sodium were heated in a reverberatory furnace, the liquid being tapped off. The present electrolytic Hall process was not invented until 1886.

The cap has been in place for fifty years and the recent repair work done on the Monument offered a chance to examine the aluminum and to determine its resistance to weathering during that fifty year period. The present widespread use of the metal makes its durability an important question.

Around the lower part of the pyramid is a large gold-plated copper band from the under side of which four lightning rod tubes of similar make-up extend downward along the edges of the stone base and thence to the ground. The band is fastened to the aluminum by four set screws. On each side of the band there is a pair of small gold-plated copper rods projecting vertically upward.

The apex of the metal pyramid has been fused and blunted by having been struck by lightning. The face of the aluminum is covered by a thin layer of oxidized material which is easily removable. Below the band the aluminum shows some pitting which is probably the result of electrolytic action. Analyses of the aluminum scraped from above and below the band show a slight percentage of copper and gold, although only very slight percentages above the band.

The Washington Monument was started in 1848, but after the monument reached a height of 152 feet work was discontinued because of insufficient funds. Work was recommenced in 1876 by Congressional decree, but in the interim the Monument had been damaged by a bolt of lightning. In 1884 the cap piece was set in place and the Monument formally dedicated. (*Metal Progress,* December, 1934.)—P. W. A.

Knives of Flame

Oxy-Acetylene Machine Cutting and Flame Machining Lower the Cost of Fabrication.

By **H. ULLMER***

LIKE CUTTING CHEESE—the oxy-acetylene cutting blowpipe demolishes a 52-ton cast iron rock crusher bowl.

Machines for guiding and moving the oxy-acetylene cutting blowpipe automatically are the most important of the recent developments in man's harnessing of flame for productive purposes. Like ribbons of fire, multiple flames of oxygen mixed with acetylene surround a jet of pure oxygen to cut steel, cast iron and other ferrous metals into intricate patterns —quickly and easily—with remarkable savings in costs over old methods.

New Methods of Production

Since 1905, oxy-acetylene cutting by hand has been widely used in demolition and maintenance work. During the last several years, the effectiveness of oxy-acetylene cutting as a means of production has been proved and tremendously multiplied by the development of machines for various repetitive cutting requirements. The operating fields of these machines range from the simple beveling of steel plates to the cutting of intricate patterns. Most of the machines can cut vertically and horizontally. Some can be adjusted to cut circles without the use of patterns. Others cut bevels, gouge grooves, and shape complicated designs.

Shape Thousands of Identical Parts

The economical continuous or intermittent production of identical regular or irregular shapes from rolled or forged steel is an outstanding accomplishment of present day oxy-acetylene cutting machines. With remarkable ease they follow templets of the desired form for the pieces to be cut. So accurate are the results that for many purposes the cut pieces can be used without machining or further finishing. Only by looking close at the smooth sides of the cut can an experienced eye tell the difference from a mechanical cut.

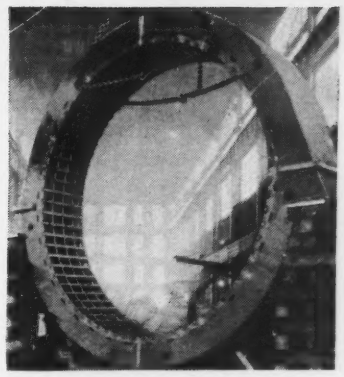
In a Wide Variety of Pieces

Some of the different pieces of equipment fabricated from oxy-acetylene shape-cut steel include: press frames of rolled steel requiring high strength and resistance to shock, gear blanks, cams in all types of intricate designs, forming dies which need little finishing before use, and flywheels often over a foot thick. In every case the shape-cut parts retain the great inherent strength and toughness of the rolled or forged steel from which they are made.

Costs Cut With Oxy-Acetylene Cutting

No great investment in machinery is needed for oxy-acetylene cutting.

ONE OR A MILLION—flame cut parts can be produced easily and cheaply by oxy-acetylene machine cutting. These dipper tooth blanks are alike as two peas in a pod. No expensive patterns or dies are required.



FLAME-CUT PARTS—are welded into assemblies like this yoke for a 25,000 KVA Water Wheel Generator.

Pattern cost is reduced to a minimum and the making and storage of expensive and intricate patterns is avoided. In most cases the machine cut shapes can be beveled easily by oxy-acetylene cutting and quickly made ready for assembly by welding, thus further reducing the cost of the finished equipment and making a more salable and a more serviceable product.

Machines Now Available

Machines of all sorts for various types of oxy-acetylene cutting and flame machining have been developed by The Linde Air Products Company, a Unit of Union Carbide and Carbon Corporation. Assistance and information as to how oxy-acetylene cutting can be economically fitted into your production operations can be obtained without obligation through Linde Sales Offices at Atlanta, Baltimore, Birmingham, Boston, Buffalo, Butte, Chicago, Cleveland, Dallas, Denver, Detroit, El Paso, Houston, Indianapolis, Kansas City, Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Phoenix, Pittsburgh, Portland, Ore., St. Louis, Salt Lake City, San Francisco, Seattle, Spokane, and Tulsa. Everything for oxy-acetylene welding and cutting—including Linde Oxygen, Prest-O-Lite Acetylene, Union Carbide and Oxweld Apparatus and Supplies—is available from Linde through producing plants and warehouse stocks in all industrial centers.

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Users of oxy-acetylene welding and cutting, and other products and processes developed by Units of Union Carbide and Carbon Corporation benefit from a most unique coordination of scientific research with manufacturing, sales and service facilities. These combined resources of a vast organization assure a full measure of satisfactory performance.

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*Chief Engineer, Service Division, The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation.

G-E *Campus News*

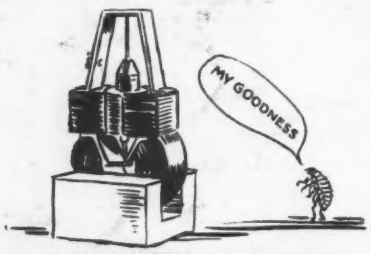
HEATING WITH COLD WATER

Reversible air-conditioning equipment, which may be adapted to either heating or cooling, depending on the season, is now in operation in a new building in Salem, N. J.

Reversing the cycle of the ordinary household refrigerator, the refrigerant absorbs heat from the water of a well which is at least 52 degrees even in coldest weather. This heat is added to that created by the work of the electrically driven compressors, and the refrigerant at 135 degrees gives up the total heat to the air of the building. Thus it is possible for an expenditure in electric energy equivalent to 100 heat units to obtain a total of 300 or 400 units for heating. Physics students will recognize this system as the heat pump.

During the summer, the process is reversed. The heat is absorbed from the air of the building. Then this heat and the heat from the compressors is dissipated in the water from the well, which then can be used for bathing, or washing dishes.

The building is completely equipped for year-round air conditioning. Besides heating and cooling, the equipment automatically controls the humidity, and cleans and circulates the air. The engineering and the planning for the installation were done by engineers of the American Gas and Electric Company and the General Electric Company, and the equipment was built and installed by General Electric.



FLEA-POWER MOTOR

New photoelectric cells, recently developed in the General Electric Research Laboratory, furnish enough energy to operate a tiny electric motor rated at four ten-millionths of a horsepower.

These "cells" differ from photoelectric "tubes" in that the cells convert light energy into electric energy, whereas phototubes do not themselves generate electricity but instead control the amount of current permitted to flow through them according to the amount of light they receive. The cells are of the selenium type, the selenium being coated with a film of platinum so thin as to be semitransparent.

Four of the cells are used to operate the motor, which in direct sunlight turns at about 400 rpm. But enough light energy is converted into electricity, when a 75-watt incandescent lamp is lighted eight inches away from the cells, to turn the motor at good speed, using three ten-thousandths of an ampere. One watt of power can be obtained from about 15 square feet of cell area in direct sunlight.

Dr. C. W. Hewlett, North Carolina State, '06, Ph. D., Johns Hopkins, '12, of the Research Laboratory was in charge of investigations that led to the development of the cells and the tiny motor.

GREEN BLUES

When the G-E "House of Magic" was exhibited at the Franklin Institute in Philadelphia not long ago, the cathode-ray oscillograph was one of the most popular features. This device, as you undoubtedly know, shows the wave shape of any sound, music, speech, or just plain noise—in the form of a moving, pale greenish-blue line on the end of the tube.

Rubinoff, the well-known radio violinist and orchestra leader, came down to see how his violin notes looked in the device. He had only a few moments in between engagements. But he became so interested after watching the gyrations of the dancing green line when he played "Humoresque" that he stayed for half an hour. He played on, and found that his violin produced green notes—even when he played the blues.

R. H. Mighell, U. of Denver, '29, of the G-E Research Laboratory, was in charge of the exhibit.

96-124DH

GENERAL ELECTRIC

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